10/554138
JC12 Rec'd PCT/PTC 20 OCT 2005

SLIDING ELEMENT

[0001] The invention relates to a sliding element as well as to the use of a carbon structure.

[0002] Antifriction or sliding elements are required wherever movable or moving parts are slidingly engaged with one another. This is the case for example with gearshift forks in gearboxes, in particular for motor vehicles. The gearshift forks engage into corresponding annular grooves on the shift collars of the gear in order to displace these for a gear change. At the same time a sliding engagement occurs between the stationary gearshift fork and the rotating clutch sleeve. With this a sliding friction occurs on the surface of the gearshift fork so that this is subjected to an increased wear. For this reason, until now gearshift forks have been coated in order to achieve an improved resistance to wear. Gearshift forks are mostly manufactured of steel plating, cast steel, bronze, aluminium or another light metal, and subsequently coated with molybdenum, chromium, polyamide or a polyimide in order to achieve an increased resistance to wear. The deposition of these coatings, for example by spraying is expensive. Furthermore with modern motor vehicle gears, for example automatic gearboxes, sequential gearboxes and dual clutch gearboxes one requires as short as possible gearshift duration times for the gear change. Shorter gearshift times require large axial forces in the transmission which lead to greater surface pressing on the sliding elements such as the gearshift forks. This leads to an increased wear of these elements.

[0003] It is therefore the object of the invention to provide a sliding element and an antifriction or sliding coating which have improved wear properties.

[0004] This object is achieved by a sliding element with the features specified in claim 1 as well as the use with the features specified in claim 11. Preferred embodiment forms are to be deduced from the respective dependent claims.

[0005] With the antifriction or sliding element according to the invention at least in one sliding section, i.e. in the section which comes into sliding engagement with a relatively moved component, a surface structure of carbon is applied. A surface structure of carbon has a considerably higher wear resistance than previously used coatings. In order to achieve the required lubricative properties, the carbon structure or the carbon material is preferably compacted, wherein a surface roughness of $Rz \leq 30$ micrometers, preferably ≤ 25 micrometers may be achieved. The surface structure however has a residual porosity. This residual porosity has the effect that the surface has an oil storage capability which ensures an adequate hydrodynamic lubrication even with a lack of oil or inadequate oil supply.

[0006] The sliding element is preferably formed as a gearshift fork, in particular as a gearshift fork for a motor vehicle gearbox, wherein the gearshift fork comprises a carrier element which at least in an engagement section is provided with a surface structure of carbon. The carrier element may, in the known manner, be manufactured preferably of steel, brass, aluminium and another suitable material. The surface structure of carbon is deposited at least in an engagement section, i.e. in a region of the gearshift fork which comes into sliding engagement with a rotating part of the gear, preferably with a sliding clutch or clutch sleeve, respectively.

[0007] The surface structure is preferably formed as a surface layer of carbon. The surface layer is deposited at least in the sliding section or engagement section. The sliding section or

engagement section is that region of the sliding element or the gearshift fork which comes into engagement with a relatively moved component, for example with a clutch sleeve. These regions due to the sliding engagement are subjected to an increased loading and need to have a particular resistance to wear. The surface layer of carbon is preferably deposited onto the carrier element at the corresponding locations as a coating.

[0008] The surfaces layer is preferably adhered to the carrier element. This may be effected by a suitable metal adhesive. For example the surface layer of carbon or the carbon layer is laminated on with a nitrile phenolic resin adhesive. But also other adhesives such as epoxy resin adhesives or adhesives based on polyacrylate are suitable to connect the surface layer to the carrier element.

[0009] It is further preferred for a connecting layer, preferably of an aramide fabric to be arranged between the carrier element and the surface layer. This ensures a greater strength of the connection between the surface layer and the carrier element.

[0010] The surface structure preferably contains carbon fibres and/or carbon particles. The arrangement of the carbon fibres is for example known from friction linings, as are used in synchronizer rings. Fabrics are formed from the carbon fibres and they may be deposited onto the carrier by way of an adhesive, for example a nitrile phenolic resin adhesive. Such arrangements of fabric of carbon fibres for synchronizer rings are for example known from the US Patent No. 5,615,758, 5,842,551 and 5,998,311 as well as from EP 0 783 638. The carbon fibres and/or carbon particles are preferably embedded into a resin material, in particular into a phenolic resin. Instead of a phenolic resin one may also use another suitable binding agent or resin, for example an epoxy resin. A material of carbon particles is particularly preferably used, as is

disclosed for a friction lining in US 4,639,392. The material disclosed there contains carbon particles of a spherical shape. With this it is the case of carbon based on petroleum coke or soot particles. A phenolic powder and in particular an epoxy-modified phenol is used. The carbon particles and the phenol powder are preferably mixed in a weight ratio of 60 to 85% carbon and 15 to 40% phenol. The mixture is heated and compressed preferably under a pressure of 2 to 7 MPa. The applied method at the same time corresponds to the method disclosed in US 4,639,392. The use of carbon particles in contrast to the use of carbon fibres has the advantage that carbon particles are considerably less expensive to produce. The manufacture and the subsequent interweaving of carbon fibres are very complicated and expensive. Carbon particles however occur very inexpensively as waste matter, for example in the form of soot or coal dust, from various processes. As a result of this, a sliding coating of carbon particles may be manufactured considerably more economically. Carbon particles furthermore permit a greater absorption of heat. This permits a complete conversion of the friction energy into heat, by which means the wear of the sliding element is minimised.

[0011] The engagement section may preferably be designed as an insert which is connected to the carrier element. This means the carrier element of the gearshift fork is not directly coated or provided with the surface layer of carbon. Instead of this a suitably coated insert or an insert with a suitable surface structure of carbon is applied into the gearshift fork. The insert may, in the known manner, be connected to the carrier element for example by way of screwing, clamping or tensioning. This arrangement permits a more economical manufacture since the gearshift forks do not need to be directly coated. Also with other sliding elements the sliding sections may be formed as inserts with a surface structure of

carbon. The insert is preferably detachably connected to the carrier element. This permits the insert to be replaced separately as a wearing part.

[0012] The insert may have a surface layer or a coating of carbon. Alternatively the insert may also be completely manufactured of a carbon structure so that a coating is no longer required.

[0013] The use of a carbon structure as a sliding coating permits the creation of a antifriction or sliding coating with improved wear properties. The carbon structure is preferably deposited onto a carrier material, such as for example a steel, in the manner of a coating.

[0014] A carbon structure which contains carbon particles and/or fibres is particularly suitable. The carbon fibres may for example be arranged as is disclosed in the US Patents No. 5,615,758, 5,842,551 and 5998,311 as well as from EP 0 783 for a friction lining of synchronizer rings. The carbon particles and/or fibres are preferably bonded by way of a binding agent. Phenolic resin is particularly suitable as a binding agent, but also other binding agents such as for example epoxy resin may be used. The used carbon particles correspond to the carbon particles and their application known from US 4,639,392.

[0015] It is useful for the carbon structure to be compacted in order to obtain as smooth as possible surface with good lubricative properties. At the same time the carbon structure however preferably has a certain residual porosity. This residual porosity has the effect that the carbon structure has a certain oil storage capacity. Due to the accommodated oil the carbon structure may ensure antifrictional or antiseizing properties given an inadequate or lacking oil supply, without damage to the sliding lining occurring. The oil stored in the pores of the carbon structure

builds up a hydrodynamic lubrication film on the surface of the carbon structure.

[0016] The invention is hereinafter described by way of example with the accompanying drawings. In these there are shown in

[0017] Fig. 1 a schematic view of a gearshift fork according to the invention,

[0018] Fig. 2 a cut-out of a gearshift fork with an insert with a surface layer of carbon,

[0019] Fig. 3 a detailed view of the gearshift fork according to a first embodiment form,

[0020] Fig. 4 a detailed view of the gearshift fork according to a second embodiment form,

[0021] Fig. 5 a detailed view of the gearshift fork according to a third embodiment form,

[0022] Fig. 6 a detailed view with a special design of the surface layer and

[0023] Fig. 7 a further detailed view of a special design of the surface layer.

[0024] Fig. 1 schematically shows a view of a gearshift fork according to the invention. The gearshift fork comprises a carrier element 2. The carrier element 2 is essentially formed in the known manner of steel sheet metal, light metal such as aluminium or another suitable material. The carrier element 2 at least in an end region is formed essentially U-shaped. The two ends 4 of the free limbs form engagement sections which may slidingly engage into corresponding annular grooves on a clutch sleeve of a motor vehicle gear box, in order to displace the clutch sleeve for a gear change. A surface layer 6 or coating of carbon is deposited at least in the region of the engagement sections 4, i.e. into the regions which come into sliding engagement. The surface layer 6

of carbon preferably consist of carbon particles or carbon fibres which are embedded in phenolic resin or another suitable resin. One preferably uses carbon particles since these are very cheap and have a high degree of dissipation compared to carbon fibres. The surface layer 6 of carbon is preferably formed as a thin plate or foil. The material is compacted during manufacture in order to have as smooth as possible surface with a surface roughness of $Rz \leq 30$, preferably $Rz \leq 25$ or 20 micrometers. At the same time however a certain residual porosity is maintained in order to ensure oil storage properties of the surface layer 6. These oil storage properties ensure an adequate antifriction property even with an deficient or lacking supply of oil. Suitable parts are punched from this surface layer 6 or foil of carbon, and these parts are adhered onto the carrier element 2. For the adhering procedure the carrier element is suitably pre-treated and its surface is activated. The carrier element for example is degreased, roughened or phosphated. Metal adhesive, for example a nitrile phenolic resin adhesive is suitable as an adhesive.

[0025] Instead of particles one may also arrange carbon fibres in the carbon layer, preferably in the form of a fabric, as is known from the US Patents 5,615,758, 5,842,551 and 5,998,311 for synchronous rings.

[0026] Fig. 2 shows a cutout section in cross section of an alternative embodiment of the invention. With this embodiment the engagement end 4 of the carrier element 2 is not directly coated. Instead of this the carrier element 2 in the region of the engagement end 4 comprises a through-hole 8 into which an insert 10 is applied. The insert 10 has a head 11 which is enlarged with respect to the bore, and on the opposite side of the carrier element 2 it is fixed on the carrier element 2 by a securing ring 12. The insert 10 preferably consists of a suitable carrier material such

as steel, brass, aluminium or another suitable light metal and is provided with a surface layer of carbon or in the manner described above. This surface layer in particular is deposited onto the sides of the head 11 which come into engagement with the hub or clutch sleeve of a gearbox. In Fig. 2 these are the side surfaces which extend parallel to the plane of the drawing. This permits the insert 10 to be designed as a separate wearing part. Furthermore the complete gearshift fork does not need to be subjected to the coating process. The complete insert may alternatively be manufactured of a suitable carbon material. The insert 10 with its head 11 may engage into an annular groove 14 of a clutch sleeve of a gearbox, the annular groove 14 is shown only schematically in Fig. 2. Furthermore, Fig. 2 shows only one side of the U-shaped gearshift fork. The oppositely lying side, i.e. the other free limb of the carrier element 2 is formed in a corresponding mirror-symmetrical manner and is likewise provided with an insert 10.

[0027] The Figs. 3 to 5 show further examples for the deposition of a surface layer 6 or carbon as has been previously described.

[0028] Fig. 3 in a detailed view shows an engagement section 4 of a gearshift fork, as for example is shown in Fig. 1. In Fig. 3 there is shown a first preferred embodiment of the deposition of the surface layer 6. In the example shown in Fig. 3 the surface layer 6 of carbon, preferably carbon particles which are embedded into phenolic resin, is deposited at the engagement section's 4 front and rear side, as well as on the end-face 7 directed to the middle. The coating on the end-face 7 is optional and is not compellingly necessary. The deposition of the surface layer 6 of carbon is effected in the manner described by way of Fig. 1.

[0029] Fig. 4 shows a further preferred embodiment of the engagement section 4. In the example shown in Fig. 4 the surface layer 6 of carbon is deposited onto an insert 16. With this the surface layer 6 is deposited at least onto the front and rear side and optionally likewise on the end-face 7 of the insert 16. A projection 18 is formed in the inside of the U-shaped insert 16 and this projection engages into a corresponding recess 20 on the engagement section 4. Furthermore, in the engagement section according to Fig. 4 there are formed holes 22 into which corresponding securing pins may engage for fastening the insert 16.

[0030] Fig. 5 in a detailed view shows the engagement section 4 of one embodiment similar to the embodiment described by way of Fig. 2. According to the example in Fig. 5 the engagement section 4 is formed as an insert 10 which at the front and rear side and preferably likewise in the inwardly directed end face is provided with a surface layer 6 of carbon. The insert 10 may alternatively be completely manufactured of the carbon material. The insert 10 is rotatably or pivotably mounted in the carrier element 2. For this, as described by way of Fig. 2, one may provide a through hole 8 in the carrier element 1, into which the insert 10 is inserted with a corresponding bolt, and is secured with the help of a securing ring 12.

[0031] Fig. 6 and 7 show special designs of the front ends 4 of the engagement sections 4, as have been described by way of Fig. 3 to 5. With this it is the case of special designs of the front end 24 on the front end of the engagement section 4, as for example drawn in Fig. 3 by way of example. The designs according to Fig. 6 and 7 may however be applied to the embodiment examples according to Fig. 4 and 5. According to the embodiment example in Fig. 6, in the region of the front end 24, a thumb-like

groove 26 is formed centrally in the surface layer 6 of the engagement section 4. According to Fig. 7, the surface layer 6 at its front end 24 comprises a chamfer 28. The groove 26 and the chamfer 28 effect an improved engagement of the gearshift fork into corresponding clutch or gearshift sleeve and favour the build-up of a hydrodynamic lubrication film of the surface layer 6 by optimising the flow of oil.

[0032] **List of References**

2	-	carrier element
4	-	engagement section
6	-	surface layer
7	-	end-face
8	-	through hole
10	-	insert
11	-	head
12	-	securing ring
14	-	annular groove
16	-	insert
18	-	projection
20	-	recess
22	-	holes
24	-	front end
26	-	groove